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Design and Implementation of Small Wind and Stair Climbing Power Generation System

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Abstract- *The world is in demand of consistent supply of electricity due to population expansion and industrial development. This research paper describes the new design of the Hybrid Renewable Energy system of small wind and stair climbing system. This system comprises an off-grid system which is controlled by Programmable Logic Controller (PLC) and monitored using* Supervisory Control and Data Acquisition *(SCADA). The stair climbing system could generate a maximum voltage of 240V, when moving from one step to another. In a small wind system 120V has been generated by a permanent magnet AC synchronous motor according to air flow rate. Both small wind and stair climbing are connected to inverter through the controller and energy from the source could be accumulated in the battery by an inverter. The power generated from these sources is given to off-grid system through 600VA inverter. The aim of the hybrid system of small wind and Stair climb is that it could be used as gadget to run home appliances independently.*

Keyword: PLC/SCADA, AC Synchronous Motor, Stair Climbing, Small Wind, Inverter

I INTRODUCTION

Worldwide demand for electricity is resolved by the use of energy that is derived from nuclear power plant. Increasing the nuclear power plant production will result in an increase in the emission of greenhouse gases and toxic gases which is harmful to the environment. Considering all these environmental issues such as the greenhouse effect, toxic gas emission there is a need to find alternate energy resources. In India, most of the rural/remote areas don't have access to electricity. To overcome this problem, there is a need to find some alternate solution.

In Renewable Energy, power for a sustainable future has discussed the state of progress for technologies for various renewable resources. Also explains the basic energy conversion processes and individual renewable sources [1]. D.B. Nelson [2] et al. Performed hybrid system using wind/ fuel cell along with a solar photovoltaic system, in this hydrogen storage tank is used as the energy storage system and also this system has been compared with traditional hybrid energy storage system. W.D. Kellogg investigated stand-alone system of wind, photovoltaic and hybrid wind/PV power generation system for remote area and examined with economic analysis for a total annual cost [3].

Kiran Boby et al. Explained the foot energy power generation system using piezoelectric transducer and applied in real time for both serial and parallel conditions. From this they conclude that power in serial was 0.7 Volts @ 3MicroAmps and in parallel was 0.7Volts @ 7MicroAmps [4]. Electric current or voltage from the piezoelectric was harvested using Euler - Bernoulli beam theory [5]. J. Ghosh et al. Proposed their research work in electrical power generation using foot step and examined the obtained results [6].

In [7] author Investigated on theoretical analysis for piezoelectric transducers, explained that the piezoelectric generator has low power

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output with deprived characteristics in voltage, current and impedance.

In [8] author described the usage of piezoelectric polymers, which can harvest the energy from people walking. In order to increase the energy from piezoelectric polymer material, electrostatic generator has been included in the piezoelectric polymers fabricated shoe. In the research article [9] foot energy was tapped and converted into electrical energy. Harvested power has been connected to the inverter for battery storage and the backup voltage was utilized.

Jarapala Murali Naik [10] projected the conversion of force into electrical energy using Permanent Magnet D.C generator and output was 12Volt. This DC 12Volt was stored in a Lead-Acid Battery. Several existing works for foot step energy harvesting has developed by using DC motor for power generation [11] and also research works are being carried out by simulation methods.

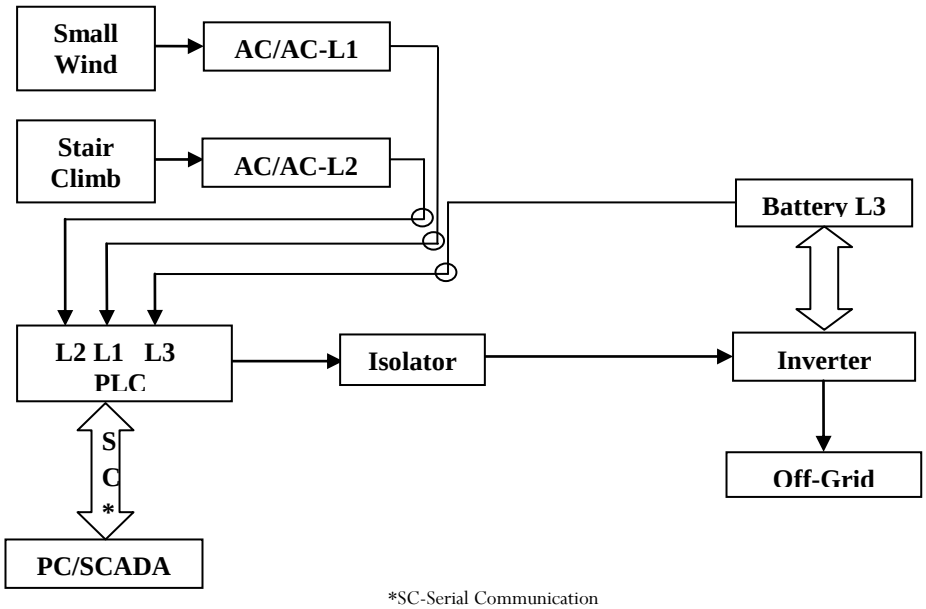
High performance synchronous motor for wind energy is implemented in [15] and the simulated test results are described using Matlab software. In [16] Stand alone system, hybrid wind and solar system are implemented in a simulation method using HOMER software by author Getachew bekele. Also elaborated the range of wind speed and solar irradiation, PV panel price and diesel price has been defined as input to the software and results have been generated.

The objective of this work is to generate the power of the combination of small wind and stair climbing. Through this combination the proposed system generates renewable power without any distraction. The organization of the rest of this paper is as follows, section 2 describes the construction of the hybrid module. Hardware description of the proposed system of HPGS is given in section 3. Section 4 gives the details of software description. In section 5, experimental results are presented. The conclusion of this paper is given in section 6.

II CONSTRUCTION OF HYBRID MODULE

The proposed framework and the idea behind the stair climbing system is when climbing the step, pressure or stress (by leg) induced in each step, the pinion wheel and the gear wheel to rotate the Permanent Magnetic AC Synchronous Motors (PMAC) which would produce an AC voltage. For every rotation, the mechanical energy is converted into electrical energy. In this system the IR sensor that is placed at the rear of the pinion wheel and this will recognize the number of rotations for each step. This system has calibrated to 240Volt for every six rotation. The output of the AC voltage is connected to inverter circuit and it could be used for recharging the battery and it can be utilized as off-grid system.

The proposed small wind module is constructed with the help of 18" three rotor blade, 33 feet hinged vane and the hub. Depending on the air flow the rotor blades, rotates the permanent magnet AC synchronous motor. Every rotation of rotor blade is evaluated by IR senor and the system has calibrated to 30 AC Volts per rotation. The experimental output of this system is calculated in real time and the test results are plotted. The Block Diagram of the Hybrid power generation system is shown in the figure 1 and specifications are described in Table 1.



*SC-Serial Communication

Figure 1. Block Diagram of Hybrid Power Generation System (HPGS)

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Table 1. Specification of HPGS

Source	PLC Line	Instrument	Power	Grid system	Remark
Small Wind	L1	AC Converter	PMAC	Off	Sensors are connected to the PLC
Stair Climb	L2	AC Converter	PMAC	Off	Sensors are connected to the PLC
Battery	L3	Inverter	L1 and L2	Off/Backup	V and I have indicated in PLC
Hybrid	L2/L1	L1 and L2 are compared by PLC			Maximum power fed to Inverter

III HARDWARE DESCRIPTION FOR HPGS

3.1 Small Wind System

The proposed small wind system operates based on air flow rate. Construction of small wind mechanism is shown in figure 2. It has been constructed with the help of bearings, rotor blade, hinging vane and gear wheel. This experimental setup is constructed in real time and the test results are verified.

Figure 2. Constructed Module of Small Wind System

3.2 Stair Climb System

The operation of this proposed stair climbing system is based on the movement from one step to another step. During this operation, simultaneously disabling and enabling processes have been done. "When the first step is climbed, power is produced in the first step, mean time the 2nd step is made disabled. Similarly, when the 2nd step is climbed, power is produced and the 1st step is made disabled". Thus the process is continued until the final step is reached. This proposed system operation is based on Kinetic Energy, where the mechanical energy is converted into the electric energy and this stair climbing system is compared with piezoelectric technology, piezoelectric transducer would produce only low voltage with low watts.

The stair climbing step system is constructed with the help of spring, rack wheel, pinion, bearing, chain drive, gear wheel, flywheel, chain sprocket and shaft. The IR Sensor placed at the rear the of pinion wheel moreover, it is used to find the number of rotations per cycle and it is illustrated in figure 3 and 4.

Figure 3. Stair Climbs System

The construction part of PMAC, power production in hybrid system is shown in figure 4, it has a 14" shaft of 10mm bore, 2 bearings and 6.5" flywheel which is built with a permanent magnet AC synchronous motor along with gear wheel produces 240V for high torque rotation.

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Figure 4. Power Production Mechanism of Hybrid System

The HPGS is designed by using the following Construction parts and it is shown in Table2.

Table 2. Construction parts of HPGS

S. NO	Name	Requirement	Qty
1	Spring	6.5"	2
2	Rack	11.5"	1
3	Gear wheel	6"	3
4	Chain sprocket	56"& 36.5"	2
5	Bearing	1.3/4" outer-16"bore	6
6	Flywheel	6.5"	1
7	Pinion	2"	1
8	Shaft	18" and 14"	4
9	AC Synchronous Motor	1000Watts	1
10	Inverter circuit with transformer	600VA	1
11	IR-Infrared Sensor	AH and AL Pins-5V	1
12	Blade	16"	3

IV SOFTWARE DESCRIPTION

The proposed framework is developed using Crouzet Programming Logic Controller (PLC). The programming language ladder diagram/Function Block Diagram is converted into binary instruction codes that can be stored in Erasable Programmable Read-Only Memory (EPROM) / Random Access Memory (RAM) [12]. Then the instruction code is debugged and executed by Millenium 3 Logic controller software. Each Input and output connection of a PLC has an address which is used for identifying the I/O bit and it organized into three regions, namely Discrete Input (I), Output relay (O), and Internal Memory (M). The Crouzet PLC configurations are shown in Table 3.

Table 3. PLC- CD 20 Configurations [13]

Pin Configuration	No. of pins Available	No. of pins Used
Discrete Inputs (I)	6	2
Analog Inputs (I)	4	4
Output Relays (O)	8	4
LED Display	36*72	Digital Display
Register Memory (M)	368bits	-

Application of Ladder diagram Program will scan and execute rung by rung and then debug the program of various functional rungs. The updated outputs are stored in output image memory (O) this output values are used to set/reset the outputs of the PLC. For the given PLC, scan time for executing the program is 0-20 ms and maximum programming capacity are 350 Blocks [14]. PLC is programmed for off-grid system based on two condition normal high power and low power. Only on the high power condition the system would be in online mode and it could recharge the battery bank. The execution of the proposed program is shown in figure 5.

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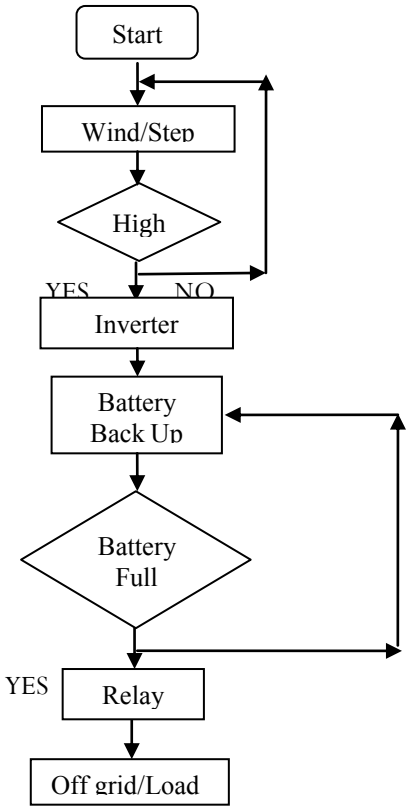

Figure 5. HPGS Flow chart

V RESULT AND DISCUSSION

A small wind system has been implemented in real time and tested with various conditions. The system has produced power at the various air flow rates and the results are shown in Table 4 and the graph is shown in Figure 6. The stair climbing system was implemented and tested with varied conditions herewith it was found that, the system produced voltage for each step and results are shown in Table 5 and graphical illustration shown in Figure 7. This unit is designed for person weighing 70 Kg. However, person below 60 kg weight can also operate, but the power produced will be low. The dual power generators are connected to Inverter circuit through an auto switch relay. This auto switch will change automatically according to the corresponding output voltage. Figure 8 proves the sine wave at the rate of 49.92 Hz by using NI-myDAQ Labview (DEI_BU_Coimbatore).

Table 4. Small wind Module

S.No.	Km/h	No. of rotation	Volts	m/s
1	1	3	120	0.3
2	0.5	2	70	0.1
3				03
4				0
5				0.1

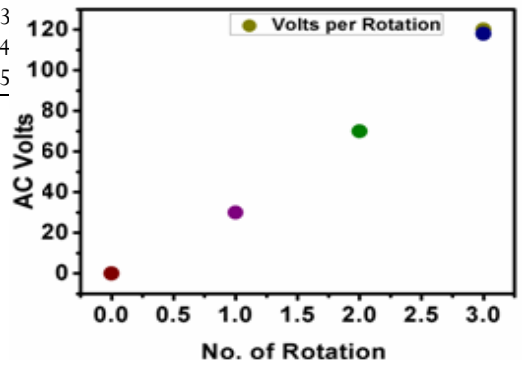

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Figure 6. Voltage rating for Small Wind

Table 5. Stair Climbing Module

S.No.	Step	AC Volts (V)	Time (Sec)	No. of Rotation
1	1	239	1	4
2	2	235	2	4
3	3	240	3	4
4	4	228	4	4
5	5	225	5	4
6	6	240	6	4

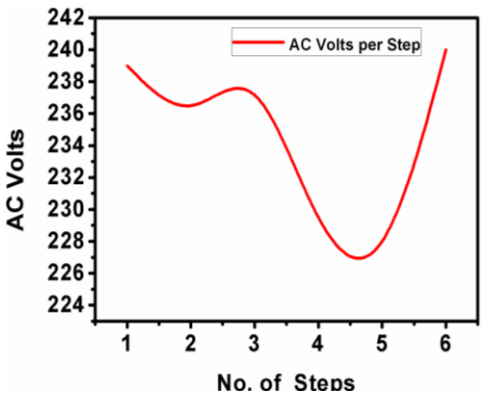

Figure 7. Voltage rating for Stair Climbing

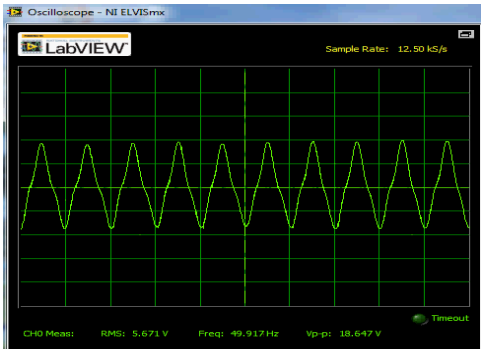

Figure 8. Frequency Response

VI CONCLUSION

The Energy Management Distribution system is performed by PLC network and monitored through the SCADA system along with HMI, thus the Power management of this gadget is totally manipulated and the power quality has been verified. In this research paper, the proposed hybrid power generation using small wind and the stair climbing system shows different characteristics of data, hence the system proves to be versatile and efficient for real time implementation. The experimental data shows the overall efficiency is nearly 50.833% and hence proposed system gives less execution time, low cost and provides high accuracy compared to the existing systems.

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